

July 23, 1963

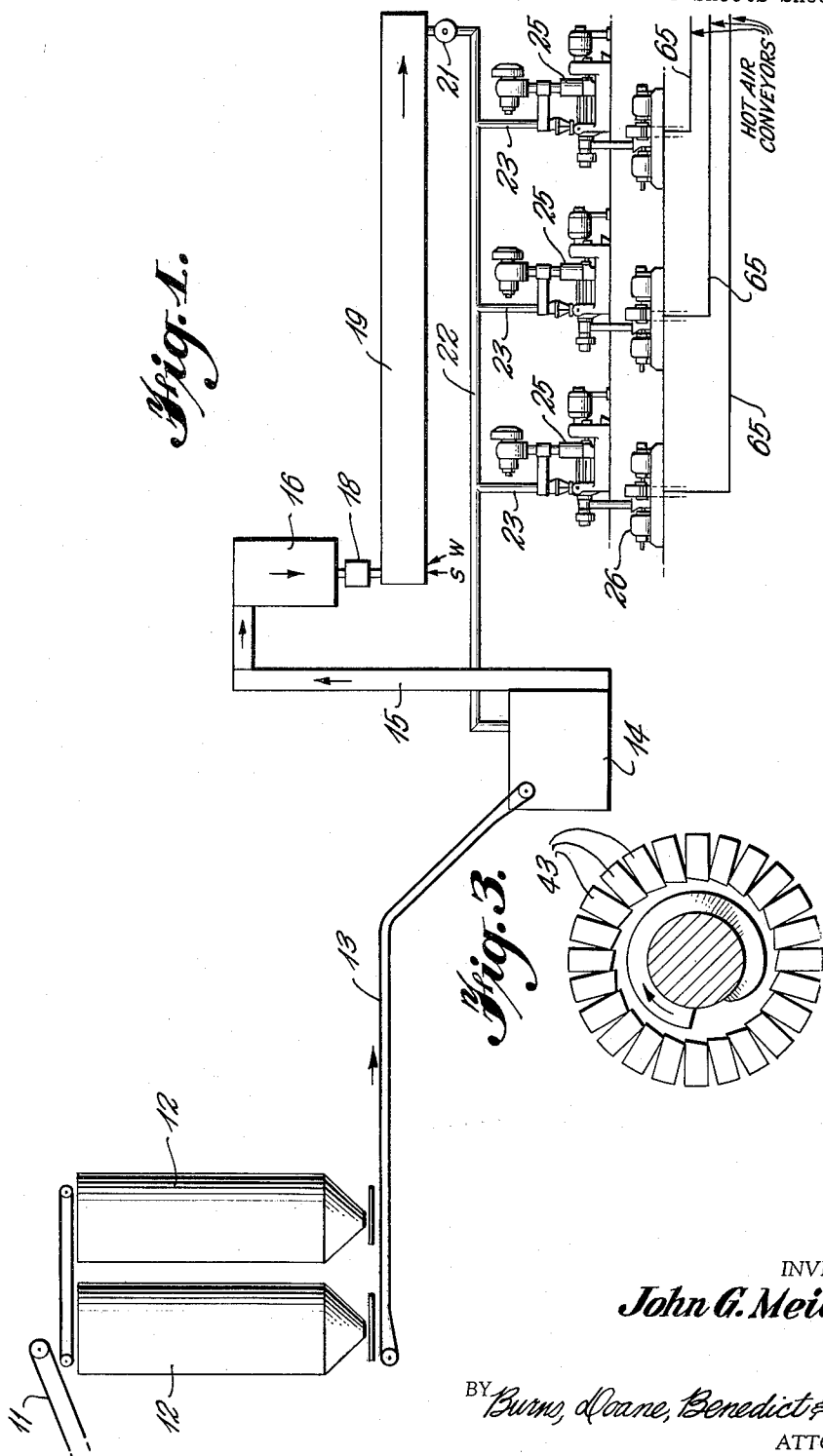
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3,098,785

METHOD OF MAKING LIGNOCELLULOSIC FIBERBOARD

Filed March 3, 1959

5 Sheets-Sheet 1



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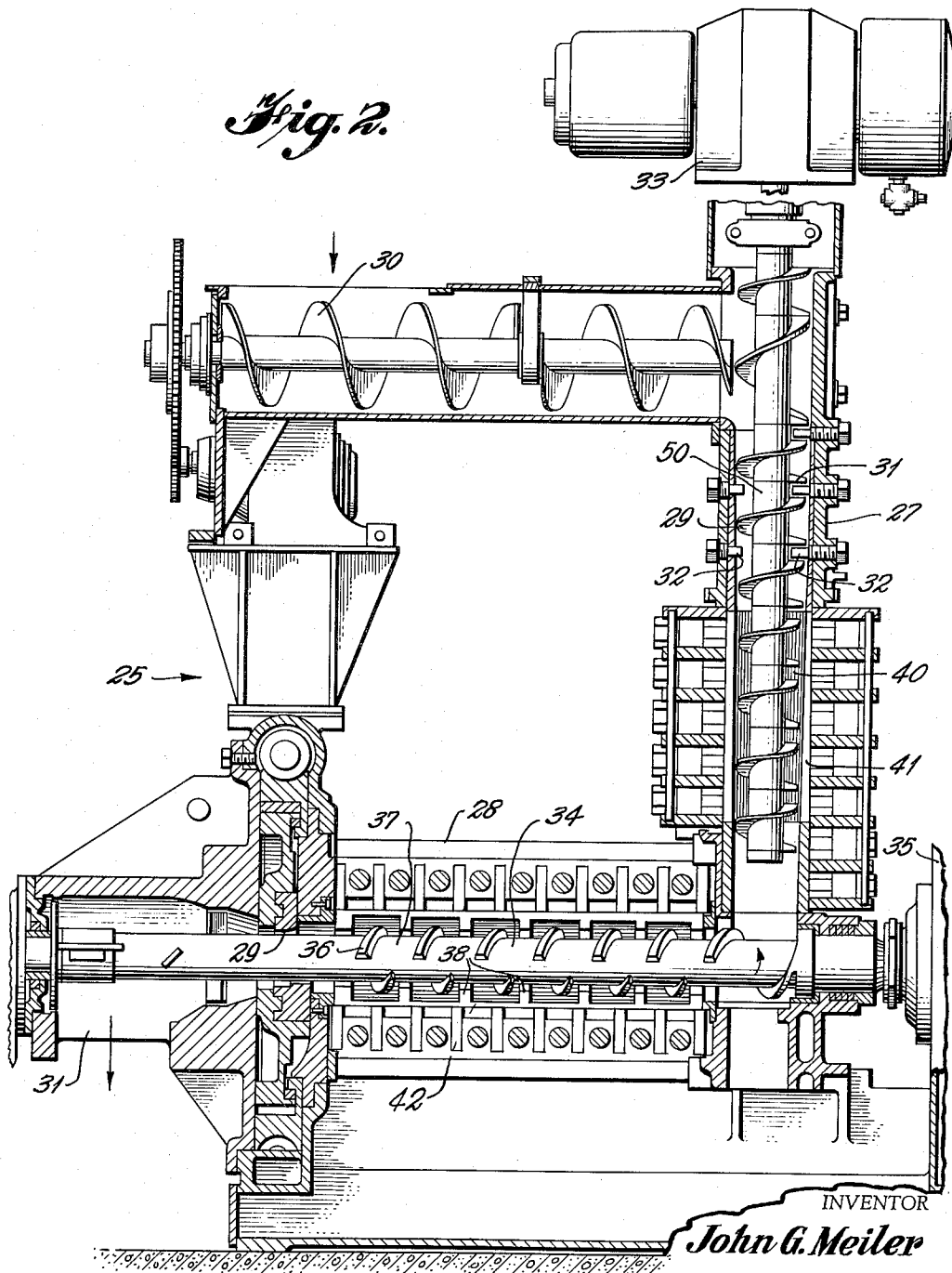
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METHOD OF MAKING LIGNOCELLULOSIC FIBERBOARD

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Fig. 2.



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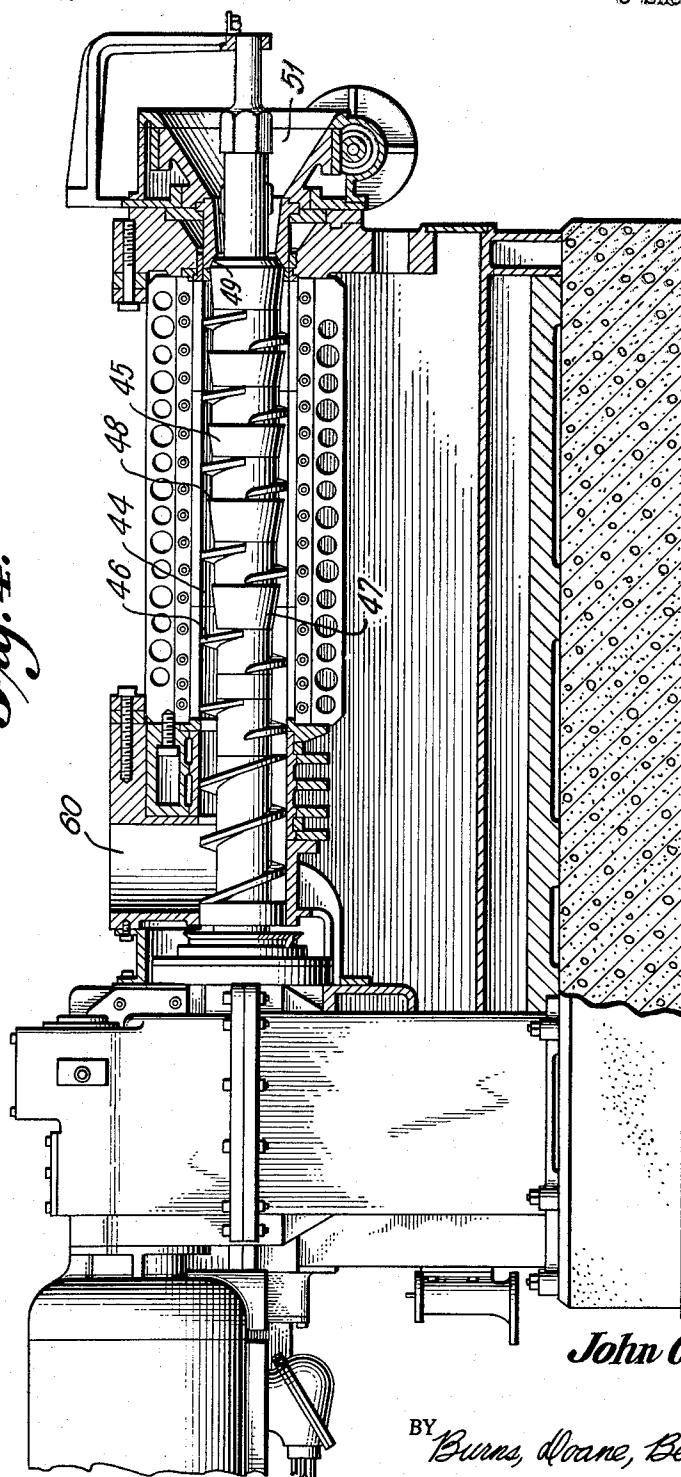
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Fig. 4.



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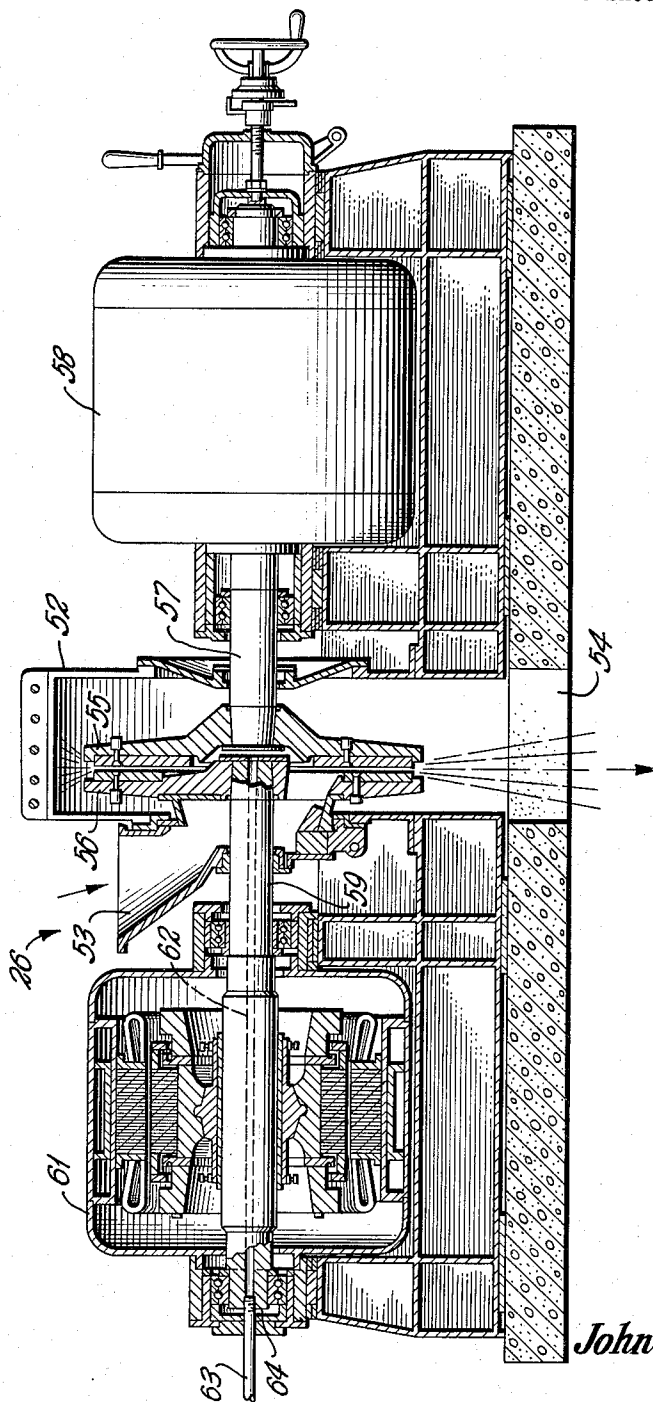
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5 Sheets-Sheet 4

Fig. 5.



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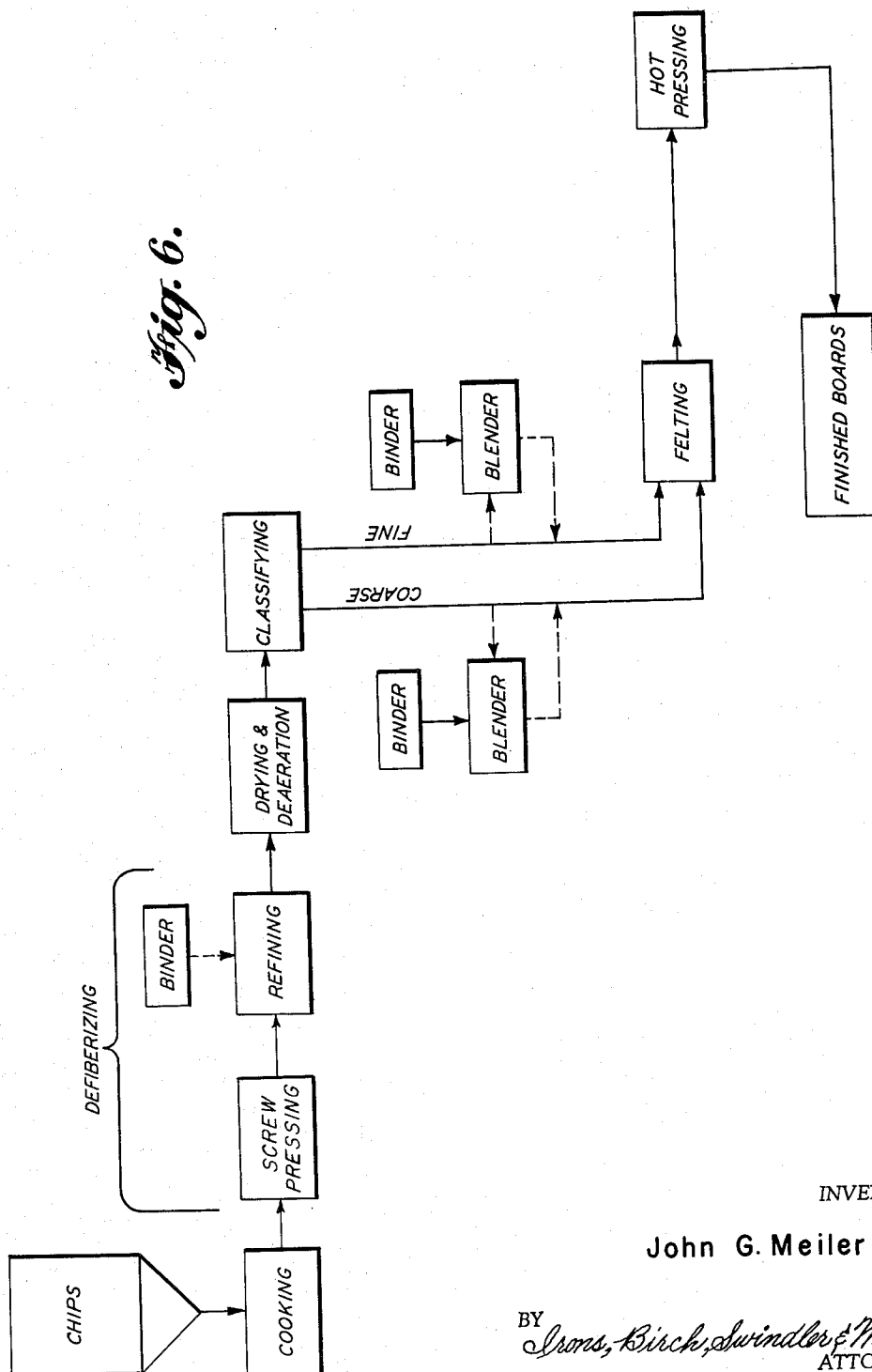
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METHOD OF MAKING LIGNOCELLULOSIC FIBERBOARD

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Fig. 6.



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METHOD OF MAKING LIGNOCELLULOSIC FIBERBOARD

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7 Claims. (Cl. 162—11)

This invention relates to the manufacture of lignocellulosic fiberboard and, more particularly, to the reduction of lignocellulose chips into fibers and the consolidation of such fibers into board.

Many different methods have heretofore been developed for the production of board products by reducing wood or other lignocellulose products to fine particles, forming such particles into a unitary mat and consolidating the mat by the application of heat and pressure into a solid board. In general, such methods may be classified into three categories; namely, the wet, wet-dry and dry processes.

In the wet process, a pulp mat is prepared from an aqueous slurry of wood fibers and formed into a thick sheet in a manner somewhat similar to the conventional paper manufacturing process and the mat is pressed into a fiberboard panel.

In the wet-dry process, a wet mat is formed in the same general manner as in the wet process; but instead of being pressed while wet, the mat is dried prior to final pressing to produce a product which is initially a low density board such as the common insulation board. This low density board is subsequently subjected while dry to heat and pressure to increase its density and produce a panel or board.

In the dry process, although an aqueous slurry is never formed, the fibers are not dry in the sense of having no moisture content. Indeed, in various prior art processes, the moisture content of fibers is varied from 5% or even below to above 100% based on the dry weight of the fiber. The term "dry process" or "dry formed" indicates that the moist fibers are conveyed in a gaseous rather than a liquid vehicle to a felter and formed into a mat which is consolidated while still moist into hardboard by the application of heat and pressure.

In all three of the above processes, the wood fibers have commonly been initially produced by subjecting wood chips to an atmosphere of steam under sufficient pressure and for a sufficient time to soften the chips to the degree that they may be easily defibred in a refiner. As is well known, however, such treatment of wood chips with steam forms water-soluble materials, chiefly polysaccharides. The amount of water solubles which are formed is dependent upon the steaming time and pressure. If such water solubles are allowed to remain in the fibers in appreciable percentages, the finished boards are low in resistance to moisture absorption. The water solubles apparently have somewhat the effect of a wetting agent and thus increase the tendency of the board to absorb moisture. Moreover, high percentages of water solubles result in staining of the surface of the board and, during certain hot pressing operations, cause clogging of the pressing equipment. In the wet and wet-dry processes, the chips are steamed for a relatively long time at a relatively high pressure, and thus high percentages of water solubles are produced. Washing operations are then employed to remove the water solubles. In the dry process, however, where the fibers are conveyed by gas instead of water and washing steps are undesirable, it is highly preferable that the steaming time and pressure be kept to a minimum to maintain the production of water solubles as low as possible.

In certain prior art dry processes, the formation of water solubles has been reduced to an acceptable level by

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limiting the degree of chip steaming. With such limited steaming, however, the chips remain so hard and tough that defibration by heretofore known techniques has resulted in fibers of inferior quality. Hardboard produced from such inferior fibers is relatively low in strength and resistance to moisture absorption and expansion caused thereby. To compensate in part for the inferior fibers, greater percentages of resin binder have been employed. If the amount of cooking is increased to improve the quality of fibers which can be produced by conventional defibration techniques, the production of excessive water solubles would be a necessary adjunct thereto. Such water solubles would have to be removed by expensive and time-consuming operations if an acceptable product is to be produced. Even then, the yield is decreased because of the loss as water solubles of a high percentage of the lignocellulose components.

To overcome the disadvantages of the prior art, a primary object of the invention is to manufacture high-quality fiberboard of lignocellulose material by an improved dry process characterized by great efficiency and high yield.

A further object of the invention is to provide a dry process of manufacturing lignocellulose fiberboard which includes the production of high-quality fibers without producing excessive water-soluble materials.

Another object of the invention is to provide an improved process for rendering more susceptible to defibration lignocellulose chips which have been steamed to an extent sufficient to effect some softening but insufficient to produce appreciable quantities of water-soluble materials and insufficient to permit adequate defibration by conventional techniques.

A specific object of the invention is to provide an improved dry process of producing hardboard which includes the steps of steaming wood chips to a limited extent to effect some softening while maintaining the formation of water solubles at a minimum, subjecting the steamed chips to great pressure in a screw press to render the chips more susceptible to defibering and thereafter defibering such chips.

Generally described, the invention embraces a process for producing fibers to be dry formed into a mat and consolidated into fiberboard which comprises exposing chips of lignocellulosic material to an atmosphere of steam at a pressure and for a time sufficient only to soften the chips but insufficient to form appreciable quantities of water solubles from lignocellulose constituents of the chips, subjecting the steamed chips to sufficient high pressure work in a screw press to render the chips more suitable for defibering, and thereafter reducing the chips to fibers. The resulting fibers are then dry formed into a mat which is subjected to consolidating temperature and pressure to produce said fiberboard.

Many different kinds of lignocellulose material may be used in the process including wood of both coniferous species, such as pine, cedar, hemlock and Douglas fir; and deciduous species, such as hickory, oak, beech, birch and maple.

The invention having been generally described, a preferred specific embodiment thereof for the accomplishment of one or more of the stated objects and others will now be set forth in detail with reference to the accompanying drawings in which:

FIGURE 1 is a schematic diagram of the cooking and defibering apparatus;

FIGURE 2 is a sectional view of one form of screw press;

FIGURE 3 is a fragmentary sectional view showing the arrangement of barrel bars in the pressing chamber of the screw press of FIGURE 2;

FIGURE 4 is a view partially in section of a modified form of screw press;

FIGURE 5 is a sectional view of the refiner; and

FIGURE 6 is a flow sheet showing a dry process for forming hardboard according to the invention.

In forming wood fibers according to the invention, logs are run through a conventional chipper as is common practice in the paper-making industry. The chips are fed by a conveyor 11 and deposited in chip silos 12 for storage. The term "chip" as used herein denotes fragments of any shape, however formed. From the silos 12, the chips are conveyed by endless belt conveyor 13 to a lower surge chamber 14 from which they are passed into an elevator 15 and then into an upper surge bin 16. The chips are then moved in controlled quantities through the valve 18 into the cooker 19. Any suitable conventional cooker, such as the Grenco continuous cooker, may be used.

It is important that the water solubles which are formed by the cooking operation be insufficient to cause the fiberboard product to exhibit excessive water absorption or a substantially stained surface or to cause clogging of the pressing equipment during certain hot pressing operations. Excellent quality boards may be produced when the steaming time and pressure is insufficient to produce over about 5% of water solubles by weight of dry fiber. The amount of water solubles produced under any given set of cooking conditions will depend upon the particular wood species cooked. It has been found that, with most species of hardwood, not over about 5% of water solubles are formed when the chips are steamed for a time of from about 1 to about 6 minutes at a pressure of from about 25 to about 50 p.s.i. Within the specified ranges, the relatively lower pressures are employed for the relatively longer times; the pressure which is used being increased progressively as the time is correspondingly decreased. Thus, the relatively higher pressures are employed for the relatively shorter times. Pressures as high as 100 p.s.i. or even higher, however, may be used if correspondingly shorter cooking times are employed to minimize the formation of water solubles. It has been found, however, that, when the chips have been subjected to the thus-limited cooking operation, they are somewhat softened but not sufficiently softened to be susceptible of defibration into high-quality fibers by heretofore known defibering operations.

The steamed chips are discharged from the cooker through a valve 21 and into a conveyor 22. Portions of the chips in the conveyor 22 are discharged into screw conveyors 23 for passage into screw presses 25, and then into the refiners 26. A slight excess of chips is cooked and the excess is returned to the lower surge bin 14.

With reference to FIGURE 2, the screw press 25 is the well-known Anderson Expeller which is illustrated and described only in sufficient detail to enable a complete understanding of its use in practicing the process of the invention. The Anderson Expeller embodies a horizontal inlet screw conveyor 30, a vertical pressing section 27, a horizontal pressing section 28, a choke 29, and an outlet 31.

The vertical pressing section 27 contains screw 50 which is driven by a suitable electric motor 33. The screw 50 embodies a plurality of short screw flights 29 separated by spaces 40. Breaker bars 32 extend into at least some of the spaces 40 to break up the stock and prevent its rotating with the screw.

Another screw 34 is positioned in the horizontal pressing section 28 and is driven by a motor 35. The screw 34 also embodies a plurality of short screw flights 36 separated by spaces 37 into which breaker bars 38 extend to break up the stock and prevent its rotating with the screw. Surrounding the screws 50 and 34 are cylindrical barrels 41 and 42, respectively. The inner walls of one or both of the barrels are defined by the inner faces of a plurality of radial barrel bars 43 as shown in FIGURE 3.

The inner face of each of the barrel bars 43 is inclined at an angle of about 7 degrees to the tangent of the circular barrel at such bar to provide a plurality of ridges around the circumference of the barrel to increase the amount of work to which material passing through the press is subjected. Stock is discharged from the horizontal pressing section 28 through the choke 29 which may be adjusted to vary the amount of pressure to which the stock is subjected.

The steamed chips are fed into the conveyor 30 and then successively passed through the vertical pressing section 27 and the horizontal pressing section 28, and discharged through the choke 29. The chips which have been cooked only to a limited extent as described and thus are relatively tough are subjected to an enormous amount of work and pressure in the screw press. One measure of the preferred amount of such work and pressure is obtained from the fact that, in the Anderson Expeller, from about 11 to about 13 h.p./ton/day is expended. In other screw presses, however, the amount of work expended to render the chips susceptible to satisfactory defibration in the refiner may be more or less than in the Anderson Expeller depending upon the characteristics of the particular machine used.

Illustrated in FIGURE 4 is an alternative form of screw press which may be used. The screw press shown in FIGURE 4 is the Bauer Pressafiner which, like the Anderson Expeller, is conventional and is shown and described only to the extent necessary for a complete understanding of its use in the practice of the process of the invention. In the Pressafiner, the chips are introduced into the inlet 60 and moved through the compression chamber 44 by screw 45 which embodies a plurality of spaced screw flights 46. The screw flights 46 are mounted on a shaft 47 which has a plurality of ridges 48 and a progressively increasing diameter toward the discharge end of the compression chamber to subject the stock to increasing work and pressure as it is passed along the chamber. A restricted throat 49 at the discharge end of the screw increases the pressure on the stock. The stock is discharged from the Pressafiner through the outlet 51. As in the Anderson Expeller, the chips are subjected to an enormous amount of pressure in the Pressafiner.

It will be understood that various configurations of screws, barrels and other screw press components, in addition to those shown in the drawings, may be employed. Generally, those configurations which increase the amount of work to which the chips are subjected are desirable.

After treatment in the screw press, the softened and loosened chips are discharged into the refiners 26 which are preferably modified Bauer refiners as shown schematically in FIGURE 1 and in more detail in FIGURE 5. The refiner comprises a housing 52 having a chip inlet 53 and a fiber outlet 54. Mounted in the housing are a pair of conventional grinding discs 55 and 56 which are mounted at closely spaced positions and are rotatable about a common axis in opposite directions to grind the stock between the faces of the discs. Specifically, disc 55 is mounted on shaft 57 which is driven by motor 58, and disc 56 is mounted on shaft 59 which is rotated by motor 61. The high pressure screw pressing enables the fibers to be reduced in the refiner to very high quality fibers comprising substantially all ultimate fibers and opened-up aggregates of ultimate fibers, i.e., loosened collections of a few individual fibers.

The modification of the Bauer refiner which applicant has effected will now be described. If desired, resin binder may be introduced into the refiner for mixture with the chips during the refining operation. The resin is introduced directly into the grinding area between the discs 55 and 56 through a drilled opening 62 which extends axially through the shaft 59. The resin is supplied through a conduit 63 which is connected to the opening 62 by a rotatable joint 64. In the conventional Bauer

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refiner, which has no drilled opening 62, the resin must be introduced through the chip inlet 53, and it tends to collect on the surfaces inside the refiner housing. In certain areas within the refiner, the resin collects between moving parts and is heated to the degree that it sets. The hardened resin is frequently ignited by friction caused by its rubbing against metal parts. Introduction through the opening 62 prevents or minimizes such resin collection in the housing.

The fibers, after discharge from the refiner, are conveyed through conduits 65 to subsequent stages of the process including a felting step, in streams of hot air or other gas which also dry the fibers to a desired moisture content preferably from 8 to 12% by weight of dry fiber. A typical overall process for forming hardboard according to the present invention is schematically illustrated in the flow sheet of FIGURE 6. The portion of the process through the refining step whereby the chips are separated into fibers which has been described in detail hereinbefore is shown in its relation to the remaining steps in the process in the flow sheet.

Before the fibers are felted into a mat, they are subjected to any desired combination of steps of air separation, classification, resin binder mixing, and the like to meet special requirements. In one typical combination of steps, the fibers are conveyed to cyclones where a desired amount of air is removed. From the cyclones, the semi-dry fibers are transferred to a classifier and separated into fine and coarse components which are deposited in different layers of the mat in the felter. Where different types or percentages of resin are desired in the various layers, the resin may be added separately to the fine and coarse fibers after classification rather than in the refiners. Preferably, the resin content of the fibers is in the range of from about 0.5% to about 10%. In addition, a water repellent such as wax may be added in a ratio of from about 0.5% to about 4%. The wax is added after the screw pressing operation. All percentages are based on the dry weight of the fibers.

The fibers, having been dried to the desired moisture content, classified into fine and coarse components and mixed with resin and wax, are air conveyed to a felter. In a typical felting operation, the fibers are blown downwardly onto a moving foraminous belt to form a multiple layer mat with coarse fibers in the middle layers and fine fibers in one or both of the outside layers. Alternatively, a single layer mat may be formed in the felter, in which case no classification of the fibers prior to felting is necessary.

The mat may be pre-compacted to a substantially self-sustaining condition and then placed in a hydraulic press between a pair of smooth heated caul plates for final curing. Sufficient temperature and pressure are applied in the press to set the resin and to consolidate the mat into fiberboard having the desired specific gravity, typically from about 0.8 to about 1.2.

It has been found that, by the process of this invention, there is obtained a high yield of fiberboard which is characterized by high strength and high resistance to moisture absorption and expansion due to moisture absorption and has surfaces substantially unblemished by stains. These desirable properties are due to the high quality of fibers which are produced and to the fact that a high percentage of water solubles is not produced in the limited cooking operation, and thus there is no need to remove great amounts of water solubles which is time-consuming, expensive, and decreases yield. In the process of this invention, the yield loss due to loss of water solubles is desirably not more than about 2% by weight of dry fiber.

In heretofore known chemical processes for making paper, the chips commonly have been steamed for a much longer period of time and at a much higher pressure than contemplated by the present invention. Such heavy steaming greatly softens the chips to the degree that

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adequate defibration could be performed either in a screw press or in a refiner alone. Thus, in such processes, screw pressing in addition to refining would have comparatively little or no effect on the strength and moisture resistance of the final product. Such processes, however, form large quantities of water solubles with their attendant disadvantages.

It has been observed that the screw press effects little or no complete separation of the tough chips into fibers. The function of the screw press is to loosen, not defiber, the chips. Defibering is performed in the refiner. It is believed that the fibers of chips steamed sufficiently lightly to avoid formation of appreciable quantities of water solubles are so stiff and tenaciously adherent to each other that, in the absence of prior screw pressing, the refiner discs tend (1) to reduce the size of the wood particles without effecting good fiber separation, and (2) to damage the stiff fibers which are separated. Conversely, it is believed that, where such lightly steamed chips are first subjected to high compression and work in a screw press, the fibers are so softened and the bonds between them so loosened that subsequent refining successfully reduces the chips into undamaged ultimate fibers and opened-up aggregates of ultimate fibers. While the above explanation as to why high pressure screw pressing of the chips prior to refining produces superior fibers is believed to be accurate, the invention is not dependent upon the accuracy of such explanation.

Further, tests indicate that where a given amount of work is performed on the chip stock in the combined screw pressing and refining operation, the over-all properties of the hardboard are improved by increasing the percentage of such work performed in the screw press. The reason for such improvement appears to be that an increase in the degree of work in the screw press improves both the strength and water resistance of the hardboard, whereas an increase in the fineness of the refiner grind when the screw press is not used does not give an appreciable increase in strength except over a very limited range of grinding conditions. Significantly, an increase in the fineness of the refiner grind after screw pressing improves the strength of the product to a materially greater extent than a corresponding increase where screw pressing is omitted.

The screw press also has the effect of removing some moisture from the chips and thus a portion of whatever small amount of water solubles are produced in the cooking operation is removed with the screw press effluent. This removal of water solubles increases the strength and water resistance of the final product to a slight degree, but naturally decreases the yield. It has also been found that both the resistance to moisture absorption and the strength of the board may be somewhat increased by adding water to the stock in the cooker, thereby increasing the chip moisture content so that more water and thus more water solubles will be removed in the screw press. Since the amount of water solubles produced by the limited cooking operation contemplated herein is relatively small, however, whatever advantages which may accrue to the removal of water solubles in the screw press is definitely secondary to the advantages which result from the improved quality of the fiber which results when screw pressing precedes refining of the relatively tough chips produced by the limited cooking operation.

The essence of this invention resides in a process wherein limited cooking leaves most of the lignocellulosic materials in the chips with very little production of water solubles and therefore little or no need to eliminate water solubles, but leaves the chips relatively tough and tenacious; high pressure screw pressing in any of various forms of screw press loosens the tough chips; and a refining operation produces a high yield of extremely high quality fibers which may be formed into fiberboard

which is high in strength, low in moisture absorption and relatively stainfree.

TABLE I
Properties at 1.00 Sp. Gr.

Example No.	No. of boards tested	Modulus of rupture, p.s.i.	Water absorption, percent	Expansion, percent	
				Thick-ness	Length
1-----	6	6,600	24	13	0.37
2-----	13	6,500	19	12	0.39
3-----	5	6,900	18	13	0.42
4-----	11	7,400	18	12	0.39
5-----	7	7,400	18	13	0.44
Average 1-5-----		7,000	19	12.6	0.40
6-----	7	5,600	20	14	0.45
7-----	8	5,800	20	13	0.48
8-----	3	6,900	21	13	0.42
9-----	3	5,300	22	13	0.45
10-----	4	6,400	21	13	0.44
11-----	13	6,200	24	14	0.50
12-----	10	6,200	21	13	0.46
13-----	2	5,200	29	16	0.51
14-----	2	6,400	23	13	0.48
15-----	6	6,200	25	13	0.46
16-----	10	5,800	22	13	0.43
Average 6-16-----		6,000	23	13.5	0.46

In all examples, chips comprising a mixture of 45% oak, 45% hickory, and 10% miscellaneous hardwoods were used. In all examples, the chips were subjected to an atmosphere of steam for from 4-6 minutes at 25 p.s.i. In Examples 1-5, the steamed chips were first subjected to high pressures work in an Anderson Expeller with an expenditure of power of from about 11 to about 14 H.P./ton/day. The screw pressed chips were then defibered in a Bauer refiner with an expenditure of power of from about 8 to about 10 H.P./ton/day. In Examples 6-16, the chips were defiberized in the Bauer refiner with an expenditure of power of about 16 to about 18 H.P./ton/day without pre-treatment in a screw press. In all of the examples, the thus-formed fibers were mixed with 2.5% resin binder and 2.5% wax and air-laid into a mat which was consolidated at high pressure for two minutes at a temperature of 465 F. to an average thickness of about 1/8 inch. Each example represents tests of a plurality of boards produced in the same run. Moreover, about eight samples from various positions in each board were tested. Thus, the test data for each example represents the average results of tests of multiple samples from each of several boards produced in the same run.

Table I shows that subjection of the chips to high pressure work in a screw press prior to defiberization materially increases both the strength and the resistance to moisture absorption and expansion caused by moisture absorption of the finished boards. It is important to note that, in Examples 6-16, the grinding conditions in the refiner, including disc setting, grinding time, power expenditure, and the like, were such as to achieve optimum or near optimum results. Thus, it is apparent that the improved results which characterize Examples 1-5 are due to the subjection of the chips to high pressure work in the screw press prior to treatment in the refiner.

Although the invention has been described with respect to a preferred embodiment thereof, it will be apparent that modifications may be made by those skilled in the art without departing from the scope of the invention as embraced by the appended claims.

I claim:

1. A process for producing consolidated lignocellulosic fiberboard which comprises exposing chips of lignocellulosic material to an atmosphere of steam at a pressure and for a time sufficient only to soften the chips but insufficient to form more than about 5% by weight of dry fiber of water solubles from constituents of the chips, subjecting the steamed chips to sufficient high pressure essentially non-defibering work in a screw press to render

the chips more suitable for defibering, and thereafter reducing the chips to fibers in a disc refiner, dry forming the resulting fibers into a mat, and subjecting the mat to consolidating temperature and pressure to produce said fiberboard.

2. A process for producing consolidated wood fiberboard which comprises exposing wood chips to an atmosphere of steam at a pressure and for a time sufficient only to soften the chips but insufficient to form more than about 5% by weight of dry fiber of water solubles from constituents of the wood, subjecting the steamed chips to sufficient high pressure essentially non-defibering work in a screw press to render the chips more suitable for defibering, thereafter reducing the chips to fibers in a disc refiner, dry forming the resulting fibers into a mat, and subjecting the mat to consolidating temperature and pressure to produce said fiberboard.

3. A process according to claim 2 wherein said chips are reduced to fibers between a pair of spaced grinding discs relatively rotating about a common axis.

4. A process for producing consolidated wood fiberboard which comprises exposing wood chips to an atmosphere of steam at a pressure of from about 25 to about 100 p.s.i. for a time of from about 1 to about 6 minutes, within the specified ranges the relatively lower pressures being employed for the relatively longer times and progressively higher pressures being employed for correspondingly shorter time periods, thus only to soften the chips while minimizing the formation of water solubles from constituents of the wood, subjecting the steamed chips to sufficient high pressure essentially non-defibering work in a screw press to render the chips more suitable for defibering, thereafter reducing the chips to fibers in a disc refiner, dry forming the resulting fibers into a mat, and subjecting the mat to consolidating temperature and pressure to produce said fiberboard.

5. A process for producing a consolidated wood fiberboard which comprises exposing wood chips to an atmosphere of steam at a pressure of from about 25 to about 50 p.s.i. for a time of from about 1 to about 6 minutes, within the specified ranges the relatively lower pressures being employed for the relatively longer times and progressively higher pressures being employed for correspondingly shorter time periods, thus only to soften the chips while minimizing the formation of water solubles from constituents of the wood, subjecting the steamed chips to sufficient high pressure essentially non-defibering work in a screw press to render the chips more suitable for defibering, thereafter reducing the chips to fibers in a disc refiner, dry forming the resulting fibers into a mat, and subjecting the mat to consolidating temperature and pressure to produce said fiberboard.

6. A process for producing consolidated wood fiberboard which comprises exposing wood chips to an atmosphere of steam at a pressure of from about 25 to about 100 p.s.i. for a time of from about 1 to about 6 minutes, within the specified ranges the relatively lower pressures being employed for the relatively longer times and progressively higher pressures being employed for correspondingly shorter time periods, thus only to soften the chips while minimizing the formation of water solubles from constituents of the wood, subjecting the steamed chips to sufficient high pressure essentially non-defibering work in a screw press to render the chips more suitable for defibering, thereafter reducing the chips to fibers between a pair of spaced grinding discs relatively rotating about a common axis, dry forming the resulting fibers into a mat, and subjecting the mat to consolidating temperature and pressure to produce said fiberboard.

7. A process for producing consolidated wood fiberboard which comprises exposing wood chips to an atmosphere of steam at a pressure of from about 25 to about 50 p.s.i. for a time of from about 1 to about 6 minutes, within the specified ranges the relatively lower pressures being employed for the relatively longer times and pro-

gressively higher pressures being employed for correspondingly shorter time periods, thus only to soften the chips while minimizing the formation of water solubles from constituents of the wood, subjecting the steamed chips to sufficient high pressure essentially non-defibering work in a screw press to render the chips more suitable for defibering, thereafter reducing the chips to fibers between a pair of spaced grinding discs relatively rotating about a common axis, dry forming the resulting fibers into a mat, and subjecting the mat to consolidating temperature and pressure to produce said fiberboard. 10

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